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Economics and the Theory of Games

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1. The theory of games deals with games of strategy, i.e., with those situations where the individual participants plan their actions with a view to winning by outwitting their opponents, designing the best course of behavior under all circumstances, etc. It is thus a much more comprehensive theory than that explaining simple games of chance which, however, became the origin and basis of the theory of probability. The theory—although still in its beginnings—is comprehensive in scope and difficult in nature; it explains, of course, first of all, games of strategy. But it does more than that, since it is believed that certain games are proper models for social, political and economic phenomena. In this paper I propose to provide some of the general economic background against which the theory (2) of games may be seen. Only a slight acquaintance with the general ideas of the theory shall be assumed. In particular, I shall not enter into any mathematical problems except by implication or reference. Instead, I shall discuss the problem whether and why the theory of games offers a better model for describing economic behavior than the models currently used.

Economic theory has, of course, always been concerned with the notion of rational behavior, i.e., with trying to determine how much of an effort may be made by an individual in attempting to obtain a stated aim and whether the necessary exhaustive account of the possible ways of reaching this aim is always feasible. Only when this question is answered in full

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(2) J. VON NEUMANN and O. MORGENSTERN: *Theory of Games and Economic Behavior*, Princeton 1944, 2nd rev. Edition 1947. Cf. also O. MORGENSTERN, "Oligopoly, Monopolistic Competition and the Theory of Games," *Proceedings American Economic Association*, May 1948, p. 10 ff.

generality—in particular allowing for any behavior of the other individuals—can there be any “rational” economic planning either for the isolated individual, or for one imbedded in a social exchange economy or finally for the various types of economic organization as a whole.

The theory of marginal utility in its different variants, extended to that of the general equilibrium of a state of free competition, is the expression these endeavours have found at present. Both rest on the idea that the economic individual always has to solve a pure maximum problem of a possibly highly complicated order. National planning too is then conceived of as the task of finding the collective maximum. Many believe this to coincide with that of a free competition economy or for which at least the same equations apply.

2. I shall now set forth briefly what the currently used model accomplishes and show where it encounters its main difficulties. Then I shall ask whether games of strategy are better suited to explain economic phenomena.

Contemporary economic theory studies on the one end of the scale the behavior of a single individual, either in isolation or operating on markets where he is assumed to be facing immutable conditions. In both cases he is trying to maximize his satisfactions or utility, and he is supposed to achieve this since he is in full control of all variables. On the other end of the scale is a market with an arbitrarily large number of individuals, both on the side of demand and of supply—in other words free competition—where each individual's share in influencing the outcome, i.e., the prices and the total quantities traded, is believed to be negligible. The theory tries to discover the principles that under these circumstances govern the market prices of all commodities and the quantities transacted or, in other words, the incomes of each factor and the ways in which they are spent. It assumes that each individual is fully informed about the possibilities of his situation and that perfect mobility of all factors exists.

Under these conditions the notion of a general equilibrium emerges in which there is “no motion but perfect mobility”. The condition is described by sets of simultaneous equations originally devised by Walras about 1870 and later variously modified in detail. It has as a rule been assumed that the equations being of equal number as the unknowns have meaningful solutions, although it was only recently that von Neumann and Wald proved their existence for more special and highly abstract

models. Frequently the question of solving the equations is dodged by the statement that the existence of—unique?—solutions can be inferred from the fact that the economy actually works. This is, of course, an entirely inadmissible argumentation. It presupposes that these equations are actually the only ones that could describe the economic reality.

Such belief is quickly shattered, if not otherwise, by reference to monopoly and monopolistic competition both of which abound in a modern economy. The theoretical problems that arise then have at a very early date been recognized as particularly troublesome. They were first treated by the mathematician Cournot and later reconsidered in a spirit of opposition, by the other French mathematician Bertrand. But I cannot deal with the history. Suffice it to say that the modern theory of monopolistic competition, as developed in the 1930's by Chamberlin, Robinson and Stackelberg, has caused a great upheaval and has led J.R.Hicks, one of the most important representatives of modern economic theory, to remark that its structure would collapse if these monopolistic elements and influences were to be included in a systematic theory⁽¹⁾. Thus we have at present no complete treatment of the main economic phenomena allowing simultaneously for the different influences of competition and monopoly.

3. What are the theoretical difficulties arising from dealing with markets situated between pure monopoly and free competition? In all these cases we have small numbers of buyers, or of sellers, or of both and, as a consequence, each is conscious of the effects of his own behavior upon that of the other individuals and *vice versa*. Thus a condition prevails that cannot be described by means of the simple devices mentioned earlier, i.e., that each individual can maximize his utility or profit by neglecting the influence of his own actions upon those of the others. Hence the great difficulties, and even the despair, of theoretical economists of constructing a universally applicable general theory in spite of the creation of several ingenious devices such as reaction curves, etc. The notion of a general economic equilibrium of the type previously indicated is derived from mechanics, but mechanics is not the model to account for the phenomena encountered when there is an interplay of monopolistic forces. These, however, are exceedingly common in any exchange economy; the strength of the tendencies towards trusts, cartels, price understandings, profit pools,

(1) *Value and Capital*, 1939, pp.83–85.

labor unions, etc., is a commonplace experience and a good measure of the practical importance of these forces.

4. This, in a few words, indicates the present situation of static economic theory. There seems to be no way out of the malaise except by reconsidering the very foundations of the theoretical approach. This means asking whether another model can be found to replace the ideas derived from mechanics and their mathematical treatment which necessarily followed the same lines. It appears that games of strategy offer the desired analogue and that the theory of games provides the solution. This is perhaps intuitively convincing. Indeed, economic practice has long guessed that such a connection can be established. It is customary, for example, to speak of a "business strategy", of the "rules of the game of the gold standard", of the "game of the stock exchange", or of the "bluffing" by labor leaders or by magnates of finance, etc. In short, the intuition of the practical man has, as often, been surprisingly good. Of particular interest is also the fear, prevailing in many business circles, of "spoiling the market". It imposes upon them a behavior of considering remoter influences and events, and thus shows that the interdependence of economic factors is most intricate and delicate. Alfred Marshall has tried to cope with this particular difficulty, but has hardly succeeded in more than drawing attention to the phenomenon.

Games of strategy account, indeed, from the outset precisely for those factors that—excepting for Cournot—were only gradually recognized in economics not only as basic but at the same time as so troublesome that they could not be fitted into the accepted doctrine of free competition. More specifically, games of strategy must by necessity first be studied for small numbers of participants—precisely the case where the convenient hypothesis of economic theory, where one is without exception dealing with clear maximum problems, most obviously breaks down. The reason is that one cannot maximize where one does not control all the variables on which the outcome depends and where the interests of the individuals are in opposition to each other. Furthermore, the role of expectations, i.e. the estimation of the influence of one's own prospective actions on those of others and *vice versa*, is of central significance there. Without accounting fully for these factors a theory of games is unthinkable. This also takes care of the need of describing the precise nature of the mutual interdependence of the behavior of the individuals which play a game or, equivalently,

act on a market. The interdependence would then also be described in conformity with the real facts of the situation rather than by means of extraneous schemes involving mechanical forces that are not even at work.

Finally, such delicate concepts as that of "exploitation", which are encountered in political and economic arguments, are likely to find a counterpart in games of strategy while they lead merely to acrimonious contests of assertions but not to theoretical penetration when they are approached by the current techniques. As an illustration I should like to point to the purely mathematical discovery of "incomplete exploitation" of a discriminated player in the 3-person zero-sum game (1) even when full information prevails. This also goes to show that discrimination is not, as often believed, a consequence of incomplete information. These solutions resemble very closely, for example, the practices of cartels which, in the interest of the standard of behavior, do not annihilate all their outsiders although it would be technically possible. Rather the cartels allow the outsiders a share in their business in order not to attract undue attention and to be able to point out to the public and the government that "competition" exists in the particular industry.

While it thus seems that the intuitive appeal of a theory of games is considerable, perhaps even immediate, once the suggestion is made, it is clear that only the success of the theory can be decisive. There are, however, difficulties in showing the superiority of the new approach by comparison with the current results. The reason is that the two (static) theories overlap so far only in a small, though basic, field in which there is not much spectacular difference in the results. Current theory, being mostly concerned with free competition or otherwise with large numbers, at least on one side of the market, deals thus primarily with problems still out of reach of the rigorous theory of games. The latter does not make it plausible that the current results are actually well founded, but the fundamental field where the theory of games makes its contribution—indeed the inner core of any economic theory—is hardly elaborated by the prevailing theory. In part, both theories overlap with each other and with commonsense—fortunately; in part, the theory of games shows results (i.e., prices) differing from both commonsense and current theory. The main difference thus at present is in the concepts, in the rigour and in the mathematical methods employed.

It is, of course, futile to discuss relative merits or possibilities in this

(1) *Op.cit.*, p. 228.

manner or at this stage of development. The fundamental differences in conception and procedure exist and further elaboration is necessary in order to show the validity of the new model.

5. It is appropriate, therefore, to study what specific demands economists must make in regard to future work on the theory of games and what specific difficulties arise or objections have been raised.

The chief demand is, of course, that the theory be extended to cover larger numbers of players, ultimately arbitrarily large n . This is undoubtedly more important than the perhaps more immediately interesting identification of games already mastered by the theory with specific economic situations. The latter would certainly be possible and should be carried out; for example, the 7-person game already treated (1) would lend itself to identification with certain important situations arising in the location of industry, etc. Yet this work would perhaps not advance the basic theory of games itself and hardly contribute toward the solution of the main problem: the existence proof of solutions for general n -person games. Some economists have formed the impression that the theory at present is not general but merely casuistic—quite misunderstanding its nature—and this type of work might strengthen their mistaken beliefs. The attitude to be adopted coincides, of course, with that the mathematician will necessarily have to take. He will clearly consider the general existence proof of solutions as the principal task for the future in this field. Therefore, the economist will have to look to the latter in order to be sure that the further pursuit and application of the theory of games is of decisive value to economics.

The economist's prime interest in the success of the extension of the number of players will naturally be whether the present basic belief that large numbers of buyers and sellers secure a free competition where each individual faces a pure maximum problem, finds any strengthening or not. As far as I, personally, can see there will be nothing of this kind, although some sort of asymptotic behavior of the solution may emerge.

The proof of the existence of solutions of all conceivable games for any number of players is of profound mathematical interest and presumably a matter of very great difficulty. In all games thus far studied, some already involving arbitrarily large numbers (2), solutions have been found to

(1) *Op.cit.*, pp. 464 ff., especially pp. 469–470.

(2) *Op.cit.*, p. 473 ff. This is the simple game with the "chief player". It has a

exist and it may be expected that this will prove to be true in full generality. It is, of course, of primary importance to be sure that this is the case, although in economics these questions have been treated lightly. After this step has been taken, it is still necessary to find the concrete solution of any given game or, in other words, to solve the concrete economic problem with which one is confronted. In this respect the situation is exactly as with any other theory in any given field. Therefore the belief of some economists that the theory of games is purely "formalistic" and does not contribute to the understanding of particular situations seems to be ill-founded. In fact, numerous games have been studied in great detail involving numerical application.

Finally, in connection with this point, there is the computational problem. This has been brushed aside in current economics for large n by reference to the millions of equations and the patent impossibility of numerical solution. Pareto's remarks in that respect are characteristic and often repeated. Instead, it was argued that practical life produced precisely "the" desired numerical solution. Now, however, it can be seen that definite numerical problems pose themselves already for 2 players, that these questions can be treated and that the idea that the empirical world "solves" any given theoretical problem is at least highly doubtful. Numerical solution, or the application of a theory, is itself an exceedingly interesting aspect of any theory. Only when this problem is mastered can one speak of a satisfactory scientific penetration of a given field. Economists may wish to acquaint themselves with this aspect of the theory of games; this is perhaps a novel feature since they are not commonly used to obtaining, or insisting on, numerical-computational solutions of their problems (1).

6. The next difficulty concerns one of the basic features of the theory of games which at the same time is one of its greatest attractions for economists: the formation of coalitions. This is a basic characteristic of games of strategy when more than two players are involved. As a rule there is than an advantage in combining in such a way that the combination of players close resemblance to pure monopoly. The solutions found for it make it likely that the current monopoly theory is far too narrow and at best considers a highly limiting case only. The complexities even of a pure monopoly appear to be much greater than at present envisaged.

(1) The theoretical problems of numerical solutions gain importance in economics now that various efforts are being made to set up and solve sets of equations numbering twenty and more.

can gain more than the sum obtained by the same players should they pursue their aim alone. When this is the case, we speak of an "essential" game; otherwise it is called "inessential". Now it is clear that economists have wrestled with two things; first with complementarity and second with the tendency towards combines or coalitions. Both are accounted for in the theory of games and the so-called characteristic function, which is non-additive, describes quantitatively, precisely those two tendencies (1). Therefore, coalitions and the laws governing their formation and strength are of prime importance to economics. They are one of the factors contributing especially towards the intuitive appeal the new theory may exercise.

It is now also clear why such importance is to be attached to the study of larger numbers of participants in a market: when there are but few, the advantages and possibilities of coalitions soon become convincing to every participant; when there are many the question arises whether the advantages of forming coalitions can be maintained or whether, as the current theory tries to show, a state of everyone for himself (free competition) results and at which point, i.e. number of participants, this transition occurs. Yet the example shows that trade unions exist, with enormously large numbers of members who are surely convinced that they fare better this way than if each were left to himself.

Clearly, when the number of participants increases, the complications of actually forming coalitions increase rapidly in order to become soon almost unimaginable. Thus, it is argued by some economists, the theory could not possibly describe, as it intends to do, what actually happens in economic life. Rather, they continue, when the number increases, instead of having more coalitions, or larger ones, there will be a tendency to neglect, or even a physical impossibility to determine, the advantages accruing from membership in coalitions and the markets would therefore tend back to the scheme of free competition where everyone is pursuing his interest alone. Such thoughts are important because they illuminate a number of points deserving attention.

To begin with, there is no doubt that both can be observed in any exchange economy: on the one hand cooperation with intent to influence

(1) From this is easily inferred that, for example, the aggregate or collective, demand curve is frequently non-additive too; a case not considered by current demand theory. Cf. O. MORGENSTERN: "Demand Theory Reconsidered", *Quarterly Journal of Economics*, February 1948.

prices and incomes, and on the other hand acceptance of existing prices by submission to the market (1). And it is at least conceivable that this is connected with the numbers of buyers or sellers (or both) and with physical difficulties of negotiations, consumption of time, etc. A theory designed to describe observable phenomena should give reasons for both tendencies.

Unquestionably, when the number of participants is small, there is no submission to a price, as is well known to economists. Even when the number of buyers should become arbitrarily large but that of the sellers remains small, so that we have an oligopoly, as for example in the American automobile or cigarette industry, all empirical evidence is that at least the sellers do not submit, but fight with each other. Often the fight ends with an open or a tacit agreement about prices or quantities. Hence the principles evolved by the theory of games are clearly seen at work, even though the theory is, as yet, not able to treat this case in full generality, i. e., for any number of participants. Thus the problem of acceptance of a price—if this be the criterion—cannot be solved by merely pointing to the fact that buyers very often do not question the prices they encounter on the market, except by either buying or not buying the commodity in question. Similarly, when the number of sellers is arbitrarily large while there are but few buyers, these will not submit to prices but also try to influence their formation. What happens, according to the theory of games, when numbers are very large on both sides, is now still unknown, so that no valid objections against the future findings can be formulated at present and the views mentioned earlier need therefore not be discussed.

Fundamentally, there is another angle to the technical difficulty of negotiating coalitions when numbers increase. It must be understood that the theory, being entirely static, like any other static theory describes equilibria, but not the way in which they are reached. The theory of games assumes that full information prevails and that the participants are able to carry out all computations and make all necessary comparisons of the different imputations. This, however, does not exceed any assumptions made by current static economic theory: in order to describe rational behavior there, it is also necessary for each individual to determine, for example, the marginal productivity of each item in an economy where there are thousands of different kinds of steel with 100,000's of different uses, to mention only one single means of production. This is not an easier assump-

(1) This distinction recalls the classical one made by Pareto in his *Manuel*; but there the monopolistic factor is not primarily due to cooperation.

tion than to think of the negotiation of coalitions among numerous players. Undoubtedly, for a realistic description of economic life both types of theories impose far too much upon the economic individuals.

Yet this is not the way to look upon the matter. In particular, however, it would be inappropriate to find nothing wrong with this assumption if used by current theory but to reject it for the theory of games. The objection misunderstands the nature of a static theory. A dynamic theory of games would be vastly superior and more useful. We hope that some time it will be constructed and it is possible that it may be simpler than the static theory. It may even be generically different from a dynamic economic theory as now envisaged. If both types of economic theory now demand that the economic individuals be endowed with virtually infinite minds there is still no reason to modify the traditional approach by relaxing this assumption rather than to apply the theory of games, since the former is found wanting in its fundamental approach to the problem economic.

7. Next, I should like to say a few words about the use of *statistical strategies*. In the theory of games the concept of a strategy is described by a set of axioms. A strategy embodies the entire planned conduct of an individual, his complete theory as to how he should play the game. If the individual chooses the strategy itself, then he is said to be playing a "pure" strategy. There is only a small class of games that are in this sense strictly determined where this conduct is possible for all players simultaneously, such that each is actually in his optimum position, and does not have to fear the discovery of his action by the opponents. In the majority of games, however, the individual has to protect himself against having his strategy "found out" while he will be trying to discover the strategy his opponents intend to pursue.

This situation is unstable. The theory shows that it is rendered stable when the players, instead of playing a pure strategy resort to probabilities with which to choose their strategies. The players are then said to be using "statistical" strategies. The main theorem of the theory assures that thereby every game becomes strictly determined and the "rational conduct" of each player is a clearly defined entity.

An illustration of this is the game of matching pennies where each player, who plays well, instead of directly choosing heads or tails—a pure strategy—will play either one in a random fashion. He thus secures for himself complete protection from the danger of having his intentions or

strategy discovered. The probability with which each pure strategy is to be played has to be computed for each particular game, considering the situation which it models.

Economists seem to have difficulties in accepting the idea of statistical strategies as representing correctly the observable behavior of economic individuals on a market. Yet they cannot and do not deny their use in playing games and in establishing the main theorem. There occur situations in economics that are very similar to that of matching pennies and the intuitive appeal of the theory of games for economists rests exactly upon that fact. But, it is asked, can one actually observe that the parties concerned do resort to statistical strategies? Yet, there is no doubt that one can empirically observe that matching pennies is played exactly as the theory shows that the game ought to be played.

The doubts seem to be misplaced. Matching pennies has only two pure strategies; an economic situation similar to that game—i.e., bilateral monopoly—has very many more and it would be easy to show what great difficulties arise in actually determining the best strategy or the probabilities with which it should be played⁽¹⁾. We have here only one of the intuitive difficulties that prevail in accepting games of strategy as a model for rational, economic behavior, while thus far we have mentioned only factors having a positive appeal. Rejection of statistical strategies is incompatible with acceptance of games of strategy as a model for social and economic situations; it arises from an incomplete understanding of the nature of the theory. It also shows that a problem of description exists, because it is not at all simple to show the use or lack of use of statistical strategies in economic life. However, even the common-sense approach is helpful, although a more complete description of behavior would require a serious effort of research. In general it is safe to say that statistical strategies are certainly in use wherever the need of secrecy exists, i.e., where one party in a market wishes to hide its intentions from the others. This occurs quite generally even where similarity to traditional “free competition” exists. And few will question that in economic life a great deal of bluffing occurs which is precisely an expression of the use of

(1) Indeed, some of the most interesting applications of the theory of games, worked out during the last two years by various authors, are concerned with precisely these questions and with the problem of solving the enormous computational difficulties that arise when one is dealing with, say, one or two hundred strategies for each opponent.

defensive statistical strategies as the game of poker shows (1). So we see that great care has to be exercised in making statements even of a purely descriptive nature in regard to games and economic life.

8. Economists might find it interesting to be more deeply concerned with parts of the theory already in existence that apparently have not yet found their attention, perhaps due to the difficulty of penetrating so deeply into the matter. I am referring to the composition and decomposition of games. In that field not only problems of the first order of interest and difficulty arise for the theory of games as such, but exceedingly interesting applications to economic situations can be made, such as to international trade, the interdependence of markets and the like. In the composition and decomposition theory two games, played separately, are viewed as one and it is shown that their solutions influence each other. One also observes that a game may be affected by the appearance of an "outside source" making either demands or offering contributions to a group of players. This outside source can never be a single player, but must consist of a group of players not smaller than three. Its offers or extractions must never be too large lest the entire social set-up be destroyed (2).

These novel phenomena already involve the constant sum games and thus are indispensable for the analysis of the variable sum games. The latter are the ones immediately important to economics, since in an exchange between individuals presumably all gain, making the sum of the advantages unequal from zero. By means of these devices the theory is able to push ahead towards the understanding of the interaction of large numbers of participants. Thus, the theory contributes towards an explanation of social phenomena of great complexity and delicacy. It is one of the main characteristics of social organization that phenomena, seemingly independent of each other, nevertheless stand in a most delicate balance. While it is quite easy to find illustrations for this in the political and social sphere there is no doubt that immediate applications to economic phenomena could readily be suggested. For this purpose it

(1) *Op. cit.*, pp. 186-219.

(2) Similarly, the notion of "imbedding" of games, or the transition from closed systems to their imbedding without interaction into all possible greater closed systems is of significance. This procedure has been very important in modern physics and it is remarkable that it can be used here too, although games are so different from physical phenomena.

would, however, be necessary to sift the existing empirico-descriptive material with the concepts in mind that the theory has evolved in this connection.

9. Another point of peculiar interest to economists—thus far apparently having escaped attention—is the statement of the theory that when complete information prevails the social maximum benefit is always reached (1). This observation belongs to the wide and important field of “welfare economics”, i.e., to the attempts to determine whether something like a social maximum can be defined, whether it exists, and by what price system and income distribution it would be assured. In other words, it is the problem of the best taxation, of economic justice, of socialism versus free enterprise, etc. It is also the problem of the measurement and the interpersonal comparison and transfer of utility, both matters that are treated to some extent in the theory of games. The literature on these topics is immense and the interest in welfare economics has never abated. Therefore, the result that according to the present state of the theory of games the social welfare is—under the stated condition—always at a maximum may sound as strange as the assertion that this is the best of all possible worlds though it may be better founded. It is impossible to discuss this proposition here any further, but it seemed sufficiently significant to direct attention to the statement and its implications.

10. Perhaps the most frequent criticism made by economists against the theory of games is that it presents itself as thoroughly static. They seem to insist that only a dynamic theory would be of interest. This attitude is no doubt the result of the attempts during the last twenty-five years to construct a dynamic economics. These efforts have a most important empirical aspect, showing up in a vast increase of descriptive data and in the beginnings of their systematic analysis. On the purely theoretical side one was led to introduce the working of the time factor into the system of the Walrasian equations or its various modifications and to study the role of expectations. As to the first, we know the doubts concerning the underlying assumptions and the general arrangement of the Walrasian system and we must therefore also doubt whether there is much point in trying to improve it by making it dynamic, rather than to remedy its basic character. As to the second, expectations are essential even under

(1) *Op.cit.*, pp. 513–514 and p. 541.

strictly static conditions and the theory of games is expressly designed to cope with the difficulties they create when describing interlocking individual plans. A theoretical study of the dynamics of expectations before their role in the static case is understood does not seem to be very promising. Descriptive accounts of expectations, for example in the business cycle, are quite a different matter and fundamentally new techniques determining them should be evolved since so very little useful information is known about them now.

While the emphasis on the static character of the theory of games stresses a point of limitation, it should be noted that it is possibly not as great as with current theory. It was suggested (1) that the distinction between statics and dynamics may be generically different in the theory of games as compared with that made in the physical sciences. This is so far only conjecture, but it must be noted that in the present formulation of a strategy, time is already included. A strategy envisages successive moves made in response to expected moves and countermoves of the opponent, so that the description of a play already takes cognizance of its extension over time. For that reason it is not *a priori* clear what is meant when a "dynamic" theory of games is demanded.

Ideas such as these, however, might occur: There may be changes in the numbers of players engaged in a game, or, equivalently, participating in a market (2), so that a game might have to be redefined accordingly. There may be the establishment of one imputation as a precedent so that others are only considered in the light of the first one, corresponding to a "leadership" and its acceptance. This might carry over towards reducing the numbers of effective players in games, an operation for which the notion of the "removable" sets of players (3) offers suggestions. There may also be envisaged the study of possible fluctuations or oscillations of imputations in connection with these operations. But it would lead too far to enter here upon these matters which are certainly not mature for consideration. There is little justification for pressing now in the direction of a dynamic theory when its desired nature cannot be properly postulated.

(1) *Op.cit.*, p. 45, p. 290.

(2) This is discussed to some extent in O. MORGENSTERN, "Demand Theory Reconsidered", *Quarterly Journal of Economics*, Vol. LXII, Feb. 1948, especially pp. 180-181 and 186-189.

(3) *Op.cit.*, p. 533-535.

In summa, therefore, nothing seems to be gained from impatience. Rather, it is advisable to develop the deeply interesting static theory wherever possible, i.e., essentially where the mathematical problems lie, and to provide for a vastly greater body of descriptive material, indispensable for the understanding of social phenomena.

11. This leads to a final brief remark on the relation of the theory of games to the empirical-descriptive part of economics. It is clear, that decisive progress in economics is not possible unless the empirical-descriptive side is developed on a scale at present hardly imagined. The theory of games will become more useful to economists if this work is accomplished. While the theory of games also depends on the description it can—as any good theory—make some contribution to it, even in its present state. It has provided us with certain precise concepts, such as imputation, solution, exploitation, discrimination, standard of behavior, etc., and they should guide new descriptive work. For example, it would be possible to look into the history of the formation of cartels, particularly into the preliminary negotiation of quotas there, into wage disputes, into the bluffing that goes on at financial markets, into the working of incomplete monopolies and the treatment of outsiders, with all these and still other concepts in mind. One would not only obtain desirable corroboration for the theory but also be led to the discovery of new facts of economic life that, requiring explanation, might help to give new directions to theoretical work which would otherwise be missed.

12. In conclusion, always speaking as an economist, I wish to restate my belief that the theory of games, in spite of the objections and difficulties mentioned, appears to be destined to play an increasing part in the further development of economic theory. It cannot be foreseen what the latter will look like in the future. But it is possible to assert that the theory of games and economic theory are already so strongly interlocked that future work on the theory of games, as indicated by the mathematical problems there, will also be of value for economics.

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